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# The surface piezoresponce and electric potential of the *c*-oriented $Sr_{0.5}Ba_{0.5}Nb_2O_6/Pt/Al_2O_3$ thin films

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The barium-strontium niobate thin films $Sr_xBa_{1-x}Nb_2O_6$ (SBN, $0 < x < 1$) are one of the most promising practically significant lead-free ferroelectric materials with good piezoelectric characteristics, for example, to create a ferroelectric RAM. The SBN lattice is of the tetragonal tungsten bronze (TTB) type and comparing to the cubic oxides with a perovskite structure allows for a greater variety of possible atomic positions in the cell. The only component of the vector of spontaneous polarization is directed along the *c*-axis.

The changing of the domain structure depending on the thin film thickness is considered for the $Sr_{0.5}Ba_{0.5}Nb_2O_6$ (SBN-50). For this purpose, X-ray diffractometry data, measurements of the piezoelectric response and surface potential were obtained.

The films were deposited on a $Pt/Al_2O_3$ substrate on a Plasma-50-SE station with the method of HF sputtering of stoichiometric ceramic target at oxygen pressures 0.45-0.55 Torr. The RF discharge power 125-195 W was chosen so as to obtain equally oriented films, which were then studied by X-ray diffractometry (diffractometer DRON-3). The surface piezoresponse and potential images were obtained on the VeecoMultimodeVS SPM using standard methods. Probe SCM-PIC, $k = 0.2$ N/m, $V_{ac} = 2\text{-}4$ V, the probe pressure force ~ 102 nN. The potential was recorded using the Kelvin probe method.

The SBN-50 films thickness was 150-230 nm. X-ray diffraction data showed characteristic reflections from the (001), (002), (211), and (311) planes. The change in the relative intensity of the (311) reflection characterizes the degree of the film texturing. The film obtained at the lowest discharge power had the smallest thickness, the highest degree of texturing, and the greatest degree of preferential orientation of the *c*-axes.

The crystallites size forming the films surface was 120-450 nm. Information on the domain structure obtained from the piezoelectric image showed that the fraction of *c*-domains decreases with increasing film thickness. The boundaries of the crystallites do not always coincide with the domains boundaries; they often divide crystallites into parts, pertaining to domains with opposite direction of the spontaneous polarization vector. In the domain boundary region, the potential amplitude is ~ 60-100 mV, and its width is ~ 50 mV.

The Fourier filtering method was used to study small-sized peculiarities of the piezoelectric image. It represent an information about the details that usually are hardly distinguishable, but can provide a very important information, for example, about polar nanoregions in relaxors, to which the SBN films belongs. It turned out that for SBN-50 film such areas are located mainly on domain boundaries. Its characteristic size is 3-4 nm.

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